PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B25B 17/00 | A1

(11) International Publication Number: WO 95/20471

(43) International Publication Date: 3 August 1995 (03.08.95)

(21) International Application Number: PCT/US95/01264

(22) International Filing Date: 31 January 1995 (31.01.95)

(30) Priority Data:
08/189,356 31 January 1994 (31.01.94) US

(71) Applicant: CANRIG DRILLING TECHNOLOGY LTD. [US/US]; Suite 1200, 515 West Greens Road, Houston, TX 77067 (US).

(72) Inventor: RICHARDSON, Allan, S.; 71 Woodacres Drive, Calgary, Alberta T2G 4X4 (CA).

(74) Agent: GORDON, Alan, H.; Fish & Richardson P.C., Suite 1200, One Riverway, Houston, TX 77056 (US).

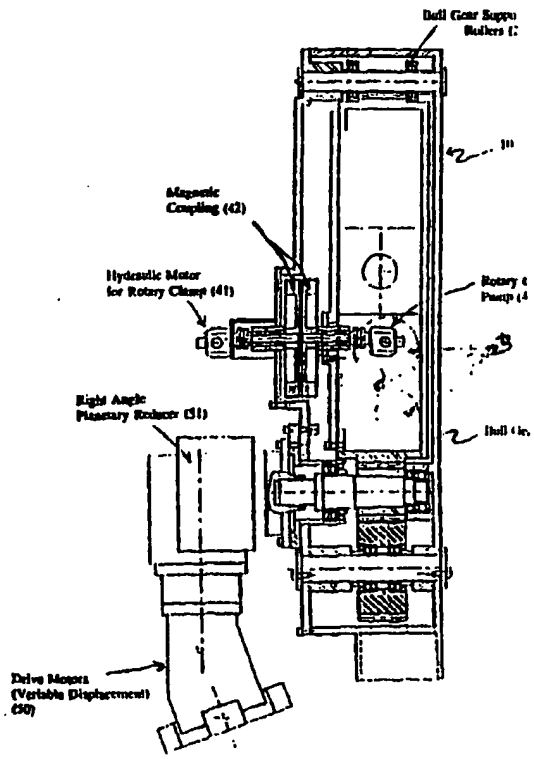
(81) Designated States: CA, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: POWER TONG WRENCH

(57) Abstract

A power tong wrench having an open slot to accommodate a range of pipe diameters, capable of making and breaking pipe threads and spinning in or out the threads and in which hydraulic power is supplied with a pump disposed within a rotary assembly (10) which pump is powered through a preferably magnetic coupling (42) to a motor (41) disposed outside the rotary assembly (10).



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**GB**	United Kingdom	**MR**	Mauritania
AU	Australia	**GE**	Georgia	**MW**	Malawi
BB	Barbados	**GN**	Guinea	**NE**	Niger
BE	Belgium	**GR**	Greece	**NL**	Netherlands
BF	Burkina Faso	**HU**	Hungary	**NO**	Norway
BG	Bulgaria	**IE**	Ireland	**NZ**	New Zealand
BJ	Benin	**IT**	Italy	**PL**	Poland
BR	Brazil	**JP**	Japan	**PT**	Portugal
BY	Belarus	**KE**	Kenya	**RO**	Romania
CA	Canada	**KG**	Kyrgystan	**RU**	Russian Federation
CF	Central African Republic	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CG	Congo			**SE**	Sweden
CH	Switzerland	**KR**	Republic of Korea	**SI**	Slovenia
CI	Côte d'Ivoire	**KZ**	Kazakhstan	**SK**	Slovakia
CM	Cameroon	**LI**	Liechtenstein	**SN**	Senegal
CN	China	**LK**	Sri Lanka	**TD**	Chad
CS	Czechoslovakia	**LU**	Luxembourg	**TG**	Togo
CZ	Czech Republic	**LV**	Latvia	**TJ**	Tajikistan
DE	Germany	**MC**	Monaco	**TT**	Trinidad and Tobago
DK	Denmark	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**US**	United States of America
FI	Finland	**ML**	Mali	**UZ**	Uzbekistan
FR	France	**MN**	Mongolia	**VN**	Viet Nam
GA	Gabon				

POWER TONG WRENCH

Background of the Invention

This invention relates to a power wrench and wrench assembly for making and breaking threads in sections of pipe and pipe couplings.

In oil and gas well drilling the drill pipe in assembled in lengths joined with threaded joints. As the pipe is fed into a well the sections of pipe are threaded together through couplings. When removing pipe the threaded sections must be disconnected and the sections of pipe stored. Inserting and removing the sections of drill pipe is called "tripping". It will be appreciated that threading and unthreading sections of pipe on tripping in and out of the well hole can be a difficult and cumbersome job. To make up the threads (or unscrew or break the threads) requires relatively high torque (rotational force). "Spinning" the pipe section after breaking (or before) making up the joints requires much less torque and is accomplished at much higher speed. Tightening and breaking joints requires the wrench to be tightly clamped on the pipe. In the early days tightening and breaking was done manually with hand wrenches (more recently with power assisted wrenches). Spinning was a separate operation, done by wrapping a chain around the pipe and pulling the chain with a winch. Today, power tong wrenches are used. These ("roughnecks") have an open slot for pipe insertion and hydraulically powered clamps to grip the pipe. The wrench is rotated by a motor mechanically attached to the wrench. Mechanical attachment of the turning mechanism limits the turn of such wrenches to about 45°. Such wrenches can develop high torque and work very well for breaking and breaking

thread joints. It will be appreciated that these wrenches work in combination with a backup wrench that holds fast the other section of threaded joint. The wrench must be removed after making or breaking the threads and a spinner (or top drive unit) attached to spin out the threaded joint. Such wrenches are exemplified by the description in U.S. Patent No. 4,348,920. Some types of these wrenches lack the capacity of handling different diameter pipe without changing pipe clamps. Since drill pipe, couplings and tapered pipe and joints are of different diameter a successful wrench must handle widely varying diameters - from about 3.5 to about 9.5 in diameter. It is a great advantage for a wrench to be able to accommodate a range of diameters without having to change the clamps. U.S. Patent No. 4,979,356 is an example of a solution to this problem. It describes a power tong wrench which can not only accommodate the desired range of pipe diameters but which is also capable of both making and breaking pipe sections and of spinning the pipe as well. The ability to do both with the same wrench is highly desirable since it accomplishes with one connection step what previously required two or more connections with a wrench and spinner. The U.S. 4,979,356 wrench comprises an inner, immediate, and outer annuli which consist of halves that can be split to mount around the pipe. Gripping is accomplishes by clamps hydraulically driven by an actuator which has a reach sufficient to accommodate various pipe diameters. The difficulty with this wrench is that it must be manually clamped around the pipe and manually disconnected. It lacks the open slot pipe entrance of the "roughneck".

It would be very desirable to have a power tong unit that can accommodate various pipe diameters and that has the making, breaking and spinning capability of the

4,979,356 power tong and the ease of assembly of the slotted roughneck wrench. This is difficult to accomplish, because of the mechanical connection of the clamp actuators and rotating assemblies.

Summary of the Invention

I have developed a wrench which accomplishes this combinations of features. It provides a slotted opening to accommodate various pipe diameters (e.g. 3.5 to 9.5 inches), can develop high torque for making and breaking, and can spin at high speed. This is accomplished by providing a non-mechanical coupling of a drive motor mounted in a wrench housing to a hydraulic pump mounted in a spinning unit. The hydraulic pump pressures a hydraulic accumulator to provide power for the clamp actuators. By non mechanical coupling the motor to the pump any limitation on rotation is eliminated. It is preferred that the coupling be magnetic. Specifically the panel power tong comprises:

A rotary jaw frame in which is mounted a bull gear rotary assembly having a cut-out section on one side sufficient to accommodate a pipe or fitting; a series of rollers mounted on the rotary jaw frame disposed around the circumference of the bull gear to support it and to allow it to rotate; opposing hydraulic cylinder clamp jaws mounted within the bull gear and operated by a hydraulic actuator which is, in turn, supplied with hydraulic fluid from hydraulic accumulators;

a hydraulic pump feeding to a hydraulic fluid reservoir disposed within the rotary assembly, which pump is operated by a non-mechanical coupling to a motor disposed in the rotary jaw frame and not on the rotary assembly;

Opposing hydraulic cylinder clamp jaws mounted in the rotary assembly and movably connected to activators;

hydraulic accumulators mounted in the rotary assembly, and a hydraulic valve connected to a hydraulic supply line to allow the hydraulic fluid to pass to and pass from the actuators that operate the rotary clamps; a least one drive motor connected through suitable gears to drive the bull gears.a rotary jaw frame in which is mounted a bull gear rotary.

The invention is also a complete assembly comprising the above described wrench together with a backup wrench mounted on a suitable housing. Other advantages of the invention will be apparent from the detached description.

Brief Description of the Drawing

Figure 1 is a side view of a power tong and frame assembly showing details of the backup wrench.

Figure 2 and Figure 3 are end and top views of Figure 1.

Figure 4 is a top view of the power tong wrench.

Figure 5 is a side view of the wrench of Figure 4 showing the drive motor, planetary reducers and hydraulic motor and pump.

Figure 6 is a schematic of the control panel.

Description of the Preferred Embodiments

In one embodiment the invention is a power tong assembly comprising the following components as illustrated in Figures 1 and 2:

1. A rotary jaw frame (10) and a back-up jaw frame (11)(Fig. 1 and 2).

2. Within the rotary jaw frame, a bull gear (20 in Fig. 5) with a cut-out on one side to allow it to be positioned around pipe such as a drill string.

3. A series of rollers (21 in Fig. 5) mounted around the circumference of the bull gear to support it laterally locate it and allow it to rotate. These rollers are mounted in the rotary jaw frame (10).

4. Opposing hydraulic cylinder clamp jaws (22 in Fig. 4) mounted within the bull gear (rotary jaw clamp).

5. A hydraulic actuation assembly (23) for the rotary jaw clamp shown in Fig. 4 and 5 and consisting of:

a. A small hydraulic pump (10)(rotary clamp pump) and oil reservoir within the rotary assembly.

b. A hydraulic motor (41) mounted on the rotary jaw frame (stationary) which powers the rotary clamp pump.

c. A magnetic, no-contact drive coupling (42) which transmits low level rotary power from the motor on the rotary jaw frame to the pump on the rotary clamp. The opposing coupling halves consist of a series of magnets arranged in a circle with alternating polarity. The coupling halves are aligned only when the rotary jaw is in its "home" position (with the cut-out section aligned to receive pipe), with the tong front openings aligned for positioning on the drill string. The rotary clamp pump is therefore driven only when the rotary clamp assembly is in the "home" position.

d. Hydraulic accumulators (nitrogen charged) that store the hydraulic energy from the rotary clamp pump for use when the rotary jaw is not in the "home" position, mounted within the rotary clamp assembly.

e. A hydraulic valve to open or close the rotary clamp and a means to actuate this

valve when the rotary clamp is in any position.

6. One or two drive motors, preferably hydraulic, and planetary gear reducers (51) mounted on the rotary jaw frame and connected to pinions which drive the bull gear (rotary clamp). It is preferred (but not necessary) that variable displacement hydraulic motors be used to avoid the need for a mechanical gear shift to enable both high-torque/low-speed (for making and breaking) and low-torque/high-speed (spinning) operations. Mechanical shifting requirement slows down the operation of the tongs.

7. A back-up clamp (60 in Fig. 3) rigidly mounted in the back-up jaw frame (11) and consisting of two opposing hydraulic cylinder clamp jaws(61).

8. A mounting means whereby the rotary jaw frame is supported on the back-up jaw frame (64) on four (4) cylinders(62) (vertical float cylinders) that have the following characteristics:

a. The rotary jaw frame is allowed to float axially a few inches on the vertical float cylinders to allow for thread advance.

b. The rotary jaw frame (64) is torsionally free of the back-up jaw frame(10) and the torque reaction is taken by a load cell for torque instrumentation. This torsional freedom of the mounting is accomplished by allowing the vertical float cylinders to pivot about a trunnion axis which is on a radius from the tong centerline.

9. The back-up jaw frame can be mounted in a drilling rig in a number of ways, such as free hanging,

frame mounted with vertical and lateral positioning or floor track mounted.

10. A hydraulic power unit for supply to all hydraulic functions.

11. Hydraulic valves for control (as shown schematically in Fig. 6) of all functions including top clamp, bottom clamp, forward/reverse rotation, vertical positioning, fore/aft positioning and vertical float and optionally,

12. A control console with electric over hydraulic for all functions and with torque instrumentation as illustrated schematically in Fig. 6.

In one embodiment the invention is the power tong comprising only the rotary jaw frame (10) and the elements 2 through 6 above.

Operation of the power tong assembly in a drilling operation is as follows:

1. The power tong normally rests in the Home position with the open side of the rotary clamp to the front for access of the drill pipe. In this position, the magnetic coupling is aligned, the rotary clamp pump driven to charge the accumulator.
2. When the tong is needed it is positioned around the pipe of the drill string and elevated to the correct position with the tong wrench on one side of a threaded joint and the backup wrench on the other.
3. The back-up wrench is closed by pressuring the back-up wrench clamp cylinders.
4. The rotary clamp is closed by actuating a rotary clamp valve means or mechanism which shifts the valve and allows hydraulic fluid to flow from the accumulator to the rotary clamp cylinders.

5. The drive motors are actuated to rotate the rotary clamp to break the connection and subsequently spin it out.

6. The rotary clamp is opened by actuating the rotary clamp valve mechanism which shifts the valve and allows hydraulic fluid to flow from the rotary clamp cylinders to the reservoir in the rotary assembly.

7. The drive motors are used to return the rotary clamp to its "home" position (the position shown in Fig. 4). This allows the long to be removed from the drill string, and allows resumption of driving rotary clamp pump to charge to accumulator in preparation for the next usage.

8. The back-up clamp is opened and the tong is repositioned into its parking position, e.g. the desired position when not in use.

This power tong and assembly has a number of advantages over other presently available systems including the following:

1. It can accommodate wide pipe diameter variation without clamp changes since the gripping elements of both the power tong and the back-up wrench are hydraulically actuated.

2. Use of the hydraulic motor drive allows make-up or break out of threads at low speed (high torque) and subsequent spinning at lower torque and high speed without changing or shifting gears. A prototype unit, as illustrated on Figures 1 - 5, is designed to develop 100,000 foot pounds of torque (useful to breakout 9 inch diameter collar) at low speed, but 40-50 RPM at low torque, as for

spinning. The lack of shifting allows smoother and safer operation than mechanical shifting.

3. The tong provides simple operation since it functions as both wrench and spinner, has no gates or latches that must be installed around on or on the pipe, an open pipe mouth to accommodate a range of pipe diameters and making it possible to mount the unit in a number of ways as convenient for use on the drilling rig. The entire operation can be operated from a single control panel as illustrated in schematic in Figure 6.

Other means of accomplishing the functions explained above are within the scope of this description and the following claim.

Claims

1. A power tong for making and breaking threaded connections and spinning such connections comprising; a rotary jaw frame in which is mounted a bull gear rotary assembly having a cut-out section on one side sufficient to accommodate a pipe or fitting; a series of rollers mounted on the rotary jaw frame disposed around the circumference of the bull gear to support it and to allow it to rotate; opposing hydraulic cylinder clamp jaws mounted within the bull gear and operated by a hydraulic actuator which is, in turn, supplied with hydraulic fluid from hydraulic accumulators;

a hydraulic pump feeding to a hydraulic fluid reservoir disposed within the rotary assembly, which pump is operated by a non-mechanical coupling to a motor disposed in the rotary jaw frame and not on the rotary assembly;

Opposing hydraulic cylinder clamp jaws mounted in the rotary assembly and movably connected to actuators;

hydraulic accumulators mounted in the rotary assembly, and a hydraulic valve connected to a hydraulic supply line to allow the hydraulic fluid to pass to and pass from the actuators that operate the rotary clamps;

a least one drive motor connected through gear means to drive the bull gears.

2. The power tong of claim 1 in which the non-mechanical coupling is magnetic and comprise opposing coupling halves having a series of magnets arranged in which with alternating polarity and which halves are configured to be aligned when the rotary jaw assembly as in position with the cut out section of the rotary assembly coincident with a cut-out section of the rotary assembly frame.

3. The power tong of claim 2 in which the drive motor is a hydraulic drive motor.

4. The power tong of claim 2 in which the hydraulic cylinder clamp jaws are two opposing clamps with sharped and slotted faces.

5. The power tong of claim 5 in which the cut out section is sized to accept pipe from about 3 to 9.5 inch diameter.

6. A power tong assembly comprising the rotary assembly of claim 1 mounted in a frame which also houses a back-up wrench assembly, which back-up wrench is connected to the rotary assembly in the frame with vertical float cylinders sufficient to allow vertical movement of the rotary assembly and the back-up wrench in respect to each other to accommodate the length of pipe threads of pipe or pipe couplings of up to about twelve inches.

7. The assembly of claim 6 in which rotary assembly, back-up wrench hydraulic valves, the drive meter and valves are controlled from a single control panel.

FIG. 1

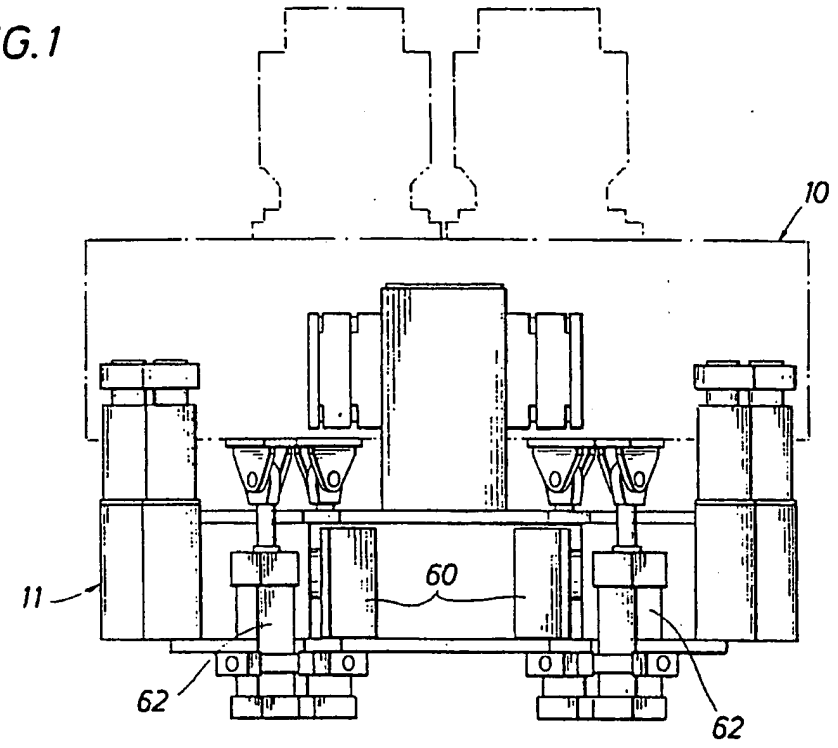
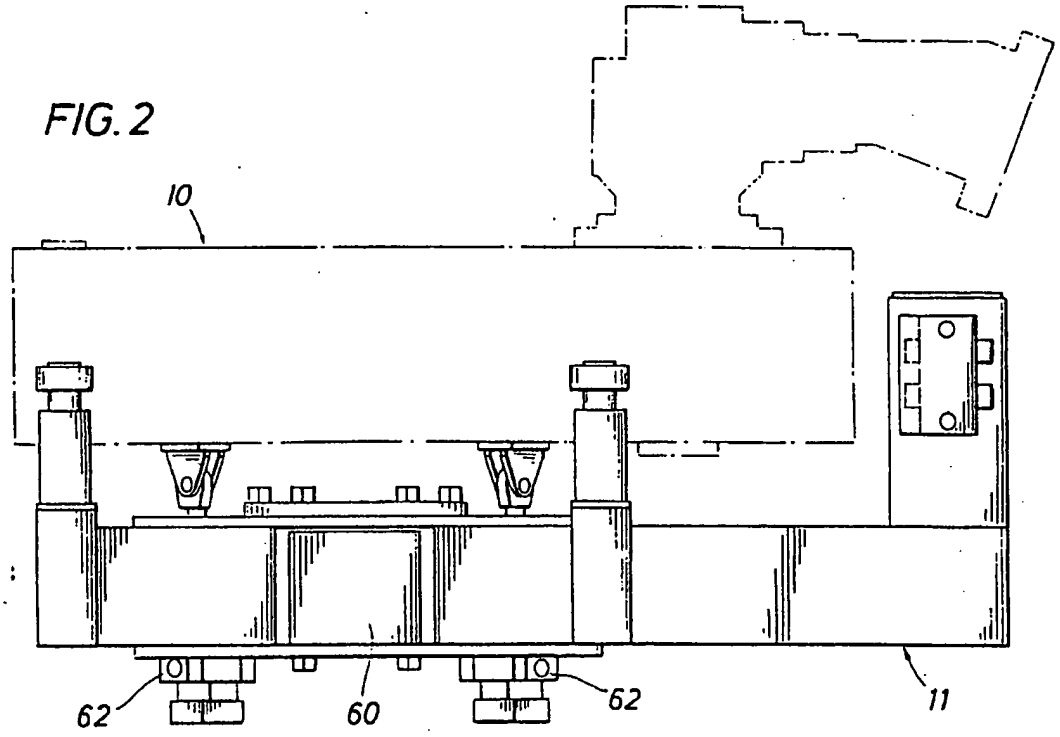


FIG. 2



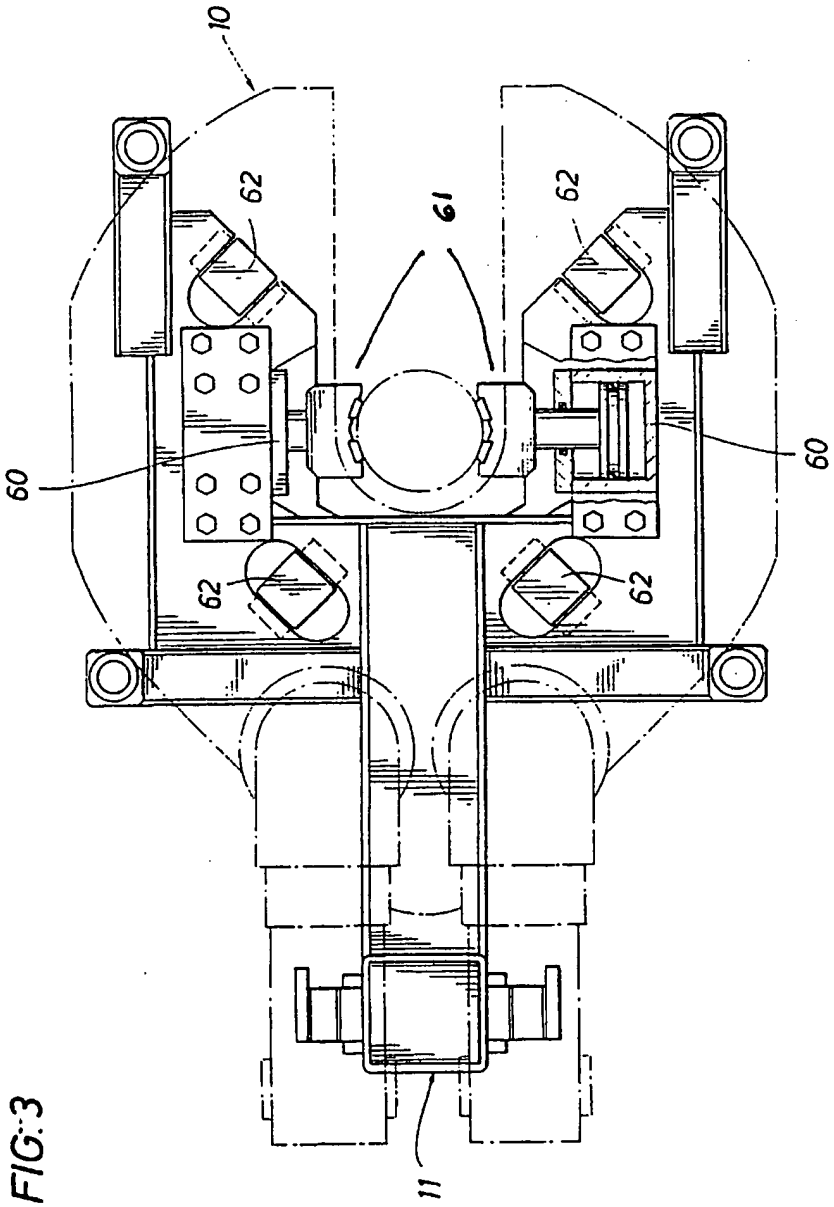


FIG. 3

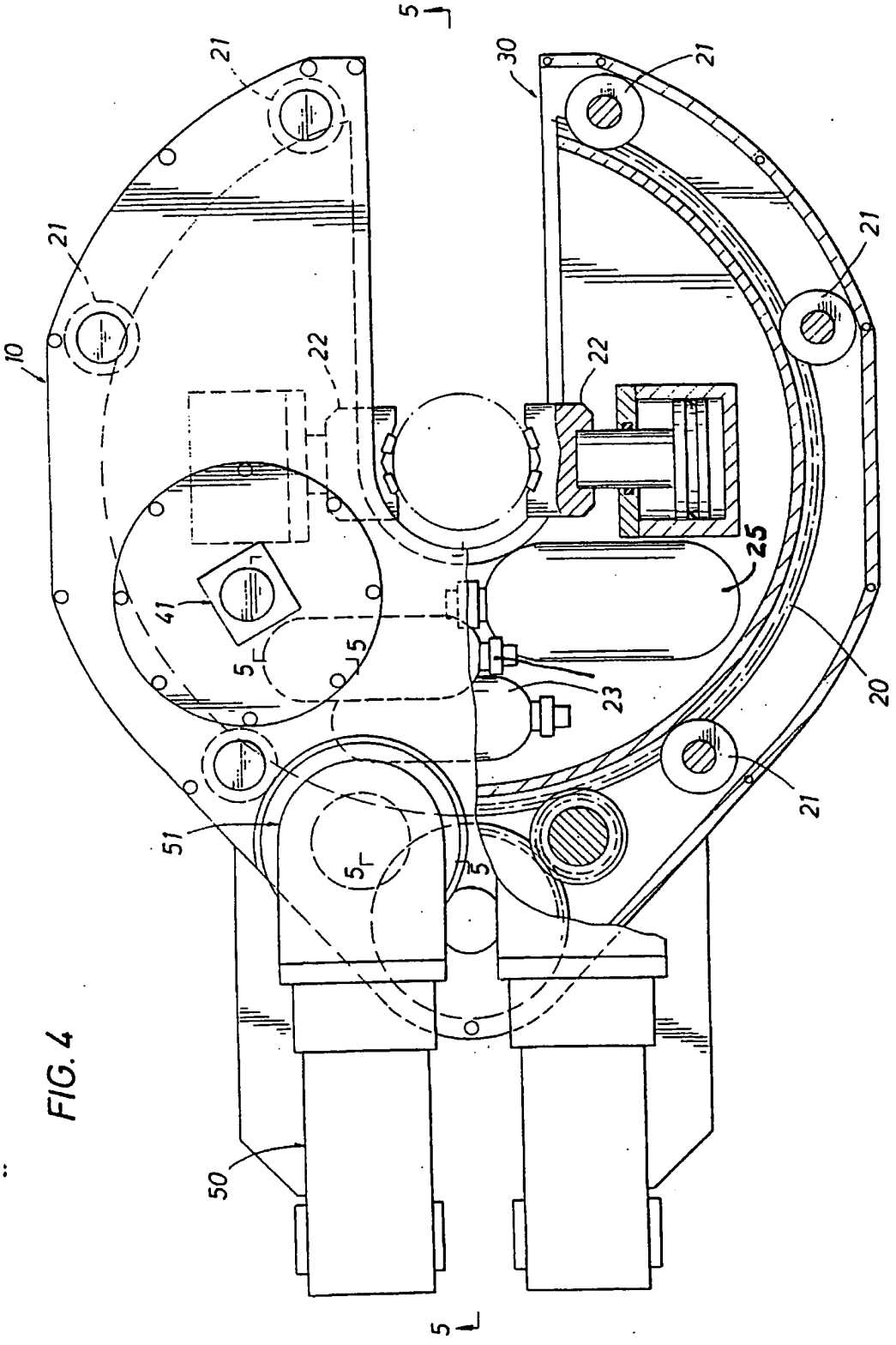
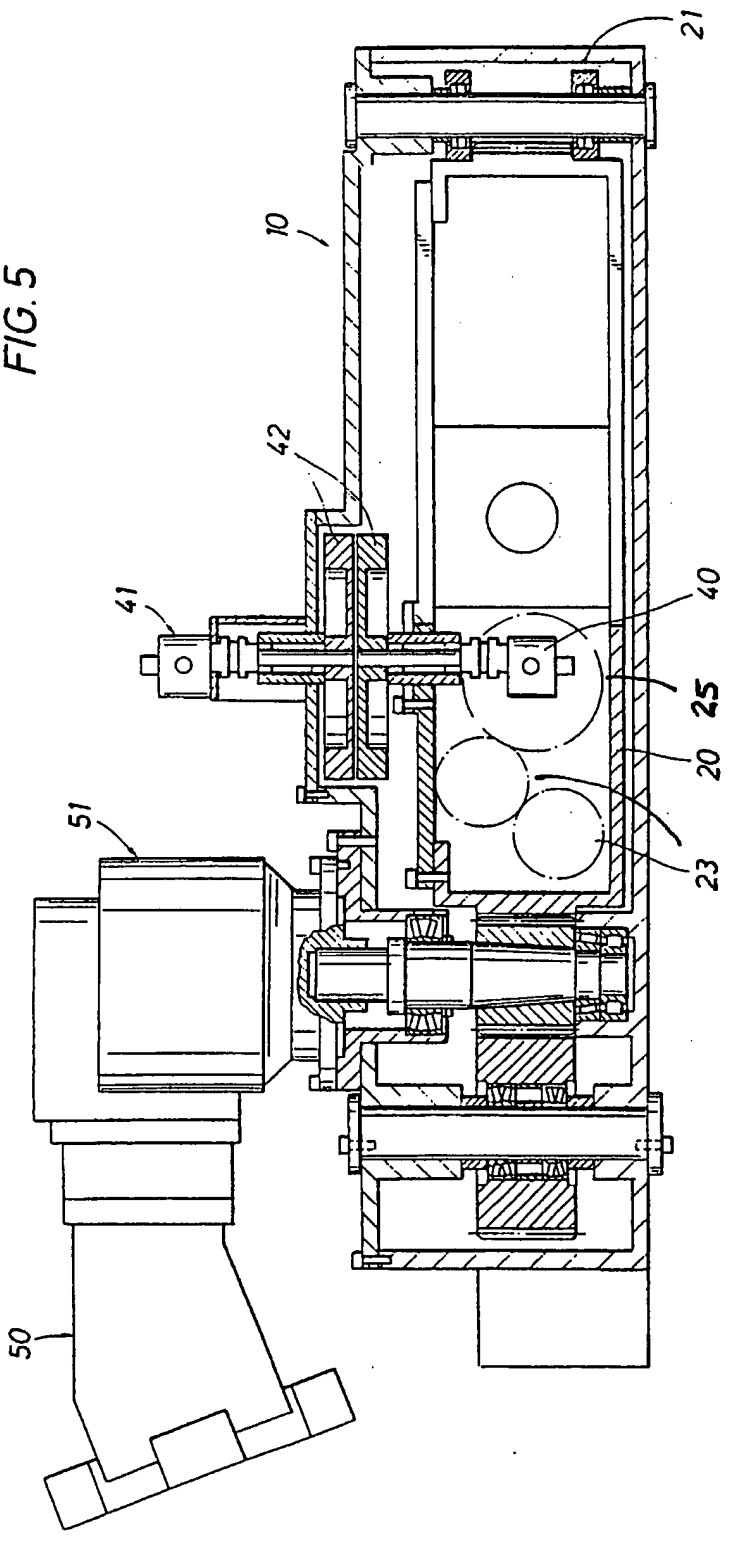


FIG. 4

FIG. 5



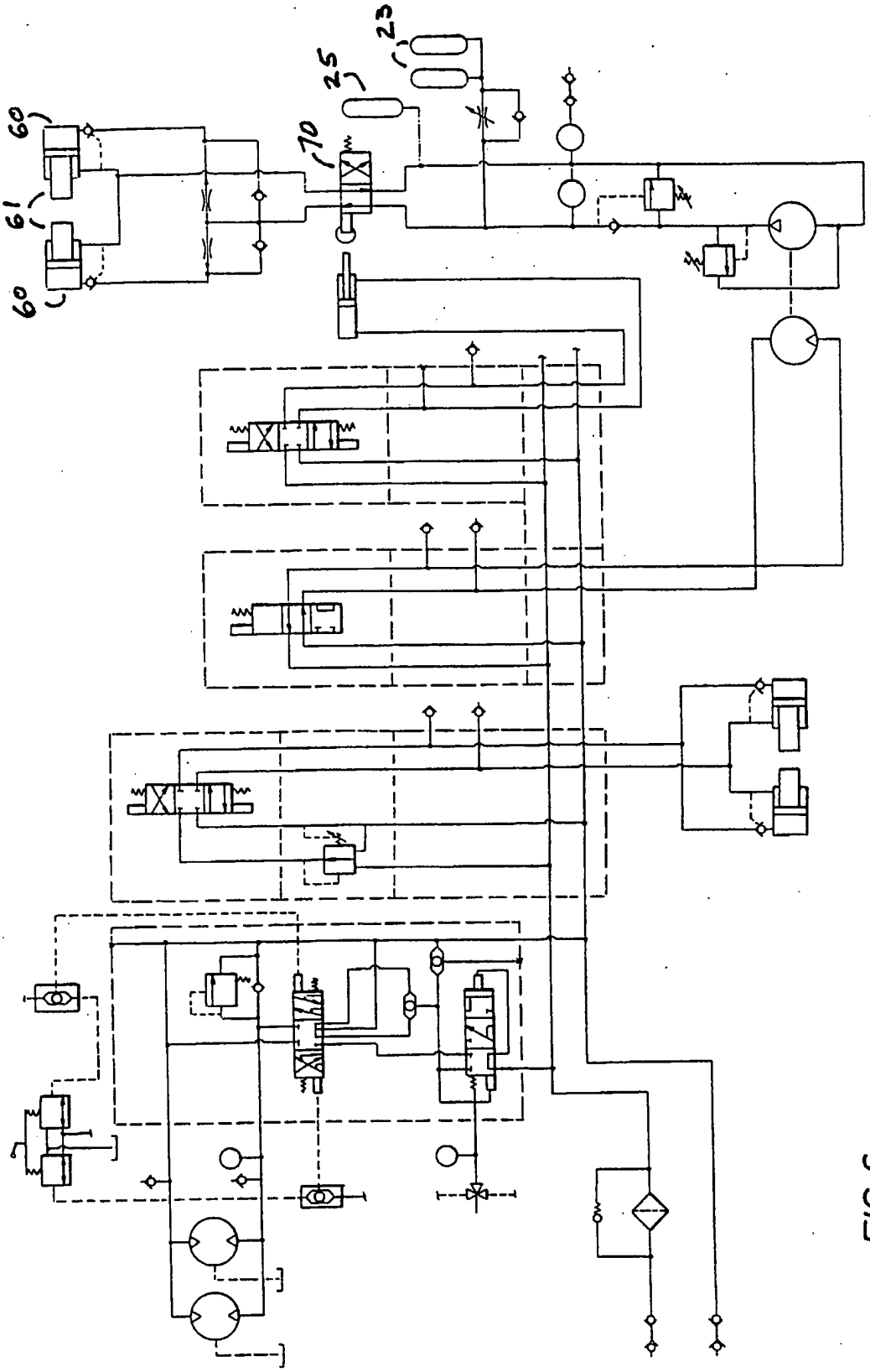


FIG.6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/01264

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B25B 17/00
US CL :81/57.16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 81/57.15, 57.16, 57.19, 57.21, 57.34

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,649,777 (BUCK) 17 MARCH 1987, SEE ENTIRE DOCUMENT	1-7
A	US, A, 4,696,206 (RENFRO) 29 SEPTEMBER 1987, SEE ENTIRE DOCUMENT.	1-7
A	US, A, 4,811,635 (FALGOUT, SR.) 14 MARCH 1989, SEE ENTIRE DOCUMENT.	1-7
A	US, A, 4,979,356 (VATNE) 25 DECEMBER 1990, SEE ENTIRE DOCUMENT.	1-7
A	US, A, 5,159,860 (PIETRAS) 03 NOVEMBER 1992, SEE ENTIRE DOCUMENT.	1-7
A	US, A, 5,161,438 (PIETRAS) 10 NOVEMBER 1992, SEE ENTIRE DOCUMENT.	1-7

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
20 MARCH 1995

Date of mailing of the international search report
10 APR 1995

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer
JAMES G. SMITH

Telephone No. (703) 308-1148

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/01264

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 5,167,173 (PIETRAS) 01 DECEMBER 1992, SEE ENTIRE DOCUMENT.	1-7